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CCL REPORT NO. 187

EFFECT OF PAINT VAPORS ON CADMIUM PLATED STEEL

FINAL REPORT

BY

WILLIAM H. DEAVER

1 OCTOBER 1965

AMCMS CODE NO. 5025.11.295
DA PROJECT NO. 1C024401A329

U. S. ARMY COATING & CHEMICAL LABORATORY
Aberdeen Proving Ground
Maryland

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ABSTRACT

Studies to determine the cause of cadmium corrosion encountered in electronic vans showed the curing of alkyd resin enamels in a closed system can create an atmosphere corrosive to cadmium plated steel. Proper curing and ventilation should prevent this occurrence. It is also possible that the incorporation of some acid reactive pigment, such as zinc oxide, in alkyd enamels would also eliminate this type corrosion. Investigation of nine additional coatings representing different types of coating vehicles indicated that epoxy, vinyl, nitrocellulose-alkyd and nitrocellulose-acrylic vehicles will not create this corrosive atmosphere.

TABLE OF CONTENTS

I. INTRODUCTION

In August 1964 a contractor installing electronic equipment in M348A2H Semi-trailer, Van, Electronic for the Missile Command encountered a powdery corrosion product on chromate treated cadmium plated hardware such as bolts, shock mounts, cable reels, springs, nuts, inserts and other miscellaneous cadmium parts. Since the electronic equipment to be installed contained many cadmium plated parts there was much concern about possible corrosion of these parts after installation of the equipment with the resultant possibility of causing malfunctions during operation.

In a letter dated 25 September 1964 the U.S. Army Tank Automotive Command, who was responsible for the procurement of the vans, requested this laboratory for technical assistance in determining the cause of this corrosion and possible action to take to eliminate it in current vans and in future production.

During discussions with the contractor and ATAC personnel it was learned that these vans had been closed up shortly after manufacture and had remained so for several months prior to being opened for installation of the electronic equipment. Analysis of this corrosion product by both the contractor and this laboratory showed it to be a cadmium formate.

It has been reported (1) that various types of organic insulation materials subjected to high temperatures and humidity (up to 200°F. and 50-100% RH) will cause corrosion of cadmium plate in closed areas. It was also found by Seabright and Trezak (2) that cadmium plated parts will corrode when in intimate contact with phenolic-base materials in the presence of warm humid air. Work at this laboratory has shown that oils used in alkyd resins, when subjected to oxidation, will form formic and butyric acid. Under confined conditions the concentration of these volatile acids can be sufficient to attack cadmium plate.

The interior construction of these vans contained many organic materials such as adhesives, insulation, paint, sealing compounds, tapes, linoleum, and paper which could contain resins and other ingredients susceptible to the formation of these corrosive vapors.

II. DETAILS OF TESTS

Initially samples of the materials used in construction of the van interiors were obtained in an effort to determine which, if any, was causing the corrosion. Specimens of each (Table I) were placed in glass jars along with cadmium plated steel bolts, both untreated and chromated treated, from both the trailers and Federal Stock Supply. In addition, the adhesives and paints were also dip applied to steel specimens and air dried 8 hours before being placed in the jars. To accelerate the test and to more nearly approach the conditions that were probably encountered as a result of the closed vans being stored outside during the summer months, the sealed jars were placed in an oven at 130°F. and examined daily for a period of 20 days. Test data, table I, showed only the TT-E-529, semi-gloss enamel caused corrosion.

In efforts to provide an immediate fix on the present vans a set of panels dip coated with TT-E-529, enamel obtained from the manufacturer and a control formulation, was air dried 7 days and another set force dried at 120°F. for

72 hours. Specimens then were subjected to the accelerated test. There was no corrosion evident with either system after 20 days exposure. On this information it would appear that if the enamel is thoroughly dried before closing of the vans, corrosion would not occur. Both the Missile Command and ATAC were notified, via teletype, of this laboratory's recommendation to thoroughly vent the vans with hot air (120°F.) for 72 hours to cure the paint and to remove the volatile organic acids. It was further recommended that ventilating louvres be installed to afford constant ventilation to prevent any further recurrence of a corrosive atmosphere.

To eliminate the possibility of future problems of this type a study was also initiated to determine if some other coatings that would not create a corrosive atmosphere could be used.

The nine organic coatings (table II) used for this study were chosen to be representative of the various types available. All coatings were formulated in the laboratory in conformance to the appropriate specification.

Duplicate test specimens for accelerated tests were prepared by dip coating 1½ X 3 inch 1010 cold rolled steel panels. Three panels for each coating were placed in a jar along with an uncoated and a chromate treated cadmium plated bolt conforming to QQ-P-416, Type I and Type II respectively. One set of jars was closed after the coating had air dried eight hours, a second set after 24 hours and a third set after 72 hours. TT-E-529, Class B enamel, was baked at 300°F. for 60 minutes and then air dried for 8, 24, and 72 hours as above. Jars were placed in an oven at 130°F. and the bolts examined daily for 20 days for signs of corrosion.

Test specimens were also prepared for outdoor exposure by painting the inside of a quart paint can with the coating under test and suspending the cadmium plated bolts from the inside of the can lid. Cans were dried the same as in the accelerated tests. These were placed on exposure at Aberdeen Proving Ground and examined for signs of cadmium corrosion after six months exposure. Uncoated steel panels and uncoated cans were used as controls for these tests.

The accelerated tests results are summarized in table III. It is clearly shown that the alkyd resin base coatings could cause corrosion on cadmium plate with or without a post treatment. One exception is noted in that the TT-P-636 primer which utilizes the same alkyd resin and approximately the same pigment loading as the TT-E-529 enamel showed no corrosion. The major difference in pigmentation is that the primer contains zinc oxide which may have reacted with the organic acids to form zinc soaps. This factor is to be investigated further. MIL-P-52108, a latex, water base paint, also caused corrosion but it was of the red rust type caused by the moisture from the paint. In all cases it is noted that the amount of corrosion decreases as the drying time is extended. There was no corrosion evident with the other coatings.

Outdoor exposure studies (table IV) confirmed the results of accelerated test.

III. DISCUSSION

From the results of this program it is apparent that if an alkyd resin enamel is to be used on the interior of the vans it must be adequately cured before closing the van. To eliminate the possibility of future problems of this type it would be desirable to change to one of the other coatings that has shown no tendency to create a corrosive atmosphere during its curing period. Since the interiors are finished in a semi-gloss light green color it is recommended that Specification MIL-L-52043 Semi-Gloss Lacquer, which covers the required color, be considered as a replacement for the TT-E-529 Enamel.

IV. REFERENCES

1. Garland, W. F., Effect of Electrical Insulation Materials on Protective Metal Finishes Under Conditions of Heat and Moisture, Rock Island Arsenal Laboratory Report No. 64-728.

2. Seabright and Trezak, Plating, 35:715-718(1948).

APPENDIX A

TABLE I

ACCELERATED TEST RESULTS

MATERIAL USED IN CONSTRUCTION OF VAN INTERIORS

Material from Vans	Results after 20 days
Plywood	No corrosion
Linoleum	No corrosion
Seal tape for aluminum post	No corrosion
Seal tape for plywood	No corrosion
Glass wool	No corrosion
Rubetex	No corrosion
Rubber covering (sponge)	No corrosion
Felt and paper (exuding)	No corrosion
MIL-L-8641	No corrosion
TT-C-50	No corrosion
Mil-S-13518	No corrosion
MIL-A-21016	No corrosion
TT-P-636	No corrosion
TT-E-529	
Air dried 8 hours	Heavy corrosion
Air dried 7 days	No corrosion
Force dried 120°F. - 72 hrs.	No corrosion
Empty jar	No corrosion

TABLE II

COATINGS EVALUATED

Specification No.	Title
TT-E-529	Enamel, Alkyd, Semi-Gloss Class A
TT-E-529	Enamel, Alkyd, Semi-Gloss Class B
MIL-E-52227	Enamel, Semi-Gloss, Quick Drying
MIL-L-52043	Lacquer, Semi-Gloss, Cellulose Nitrate
MIL-L-14486	Lacquer, Vinyl Resin, Semi-Gloss
MIL-L-19537	Lacquer, Acrylic-Nitrocellulose Gloss
MIL-P-52108	Paint, Water Emulsion Type
MIL-P-52192	Primer Coating, Epoxy
TT-P-636	Primer Coating, Synthetic, Wood and Ferrous Metal

TABLE III

ACCELERATED TEST RESULTS

20 Days In Oven At 130° F.

Specification No. of Organic Coating	8 hours drying	24 hours drying	72 hours drying
TT-E-529, Class A	Heavy corrosion	Medium corrosion	Light corrosion
TT-E-529, Class B	No corrosion	No corrosion	No corrosion
MIL-E-52227	Heavy corrosion	Medium corrosion	Light corrosion
MIL-L-52043	No corrosion	No corrosion	No corrosion
MIL-L-14486	No corrosion	No corrosion	No corrosion
MIL-L-19537	No corrosion	No corrosion	No corrosion
MIL-P-52108	Heavy corrosion (red rust)	Light corrosion (red rust)	Trace corrosion (red rust)
MIL-P-52192	No corrosion	No corrosion	No corrosion
TT-P-636	No corrosion	No corrosion	No corrosion

TABLE IV

OUTDOOR EXPOSURE TEST RESULTS

6 Months

Specification No. of Organic Coating	8 hours drying	24 hours drying	72 hours drying
TT-E-529, Class A	Heavy corrosion	Medium corrosion	Light corrosion
TT-E-529, Class B	No corrosion	No corrosion	No corrosion
MIL-E-52227	Heavy corrosion	Medium corrosion	Light corrosion
MIL-L-52043	No corrosion	No corrosion	No corrosion
MIL-L-14486	No corrosion	No corrosion	No corrosion
MIL-L-19537	No corrosion	No corrosion	No corrosion
MIL-P-52108	Light corrosion	Trace of corrosion	No corrosion
MIL-P-52192	No corrosion	No corrosion	No corrosion
TT-P-636	No corrosion	No corrosion	No corrosion

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APPENDIX B

HEADQUARTERS
UNITED STATES ARMY TANK-AUTOMOTIVE CENTER
WARREN, MICHIGAN 48090

In Reply Refer To:
SMOTA-RCM.3

25 September 1964

SUBJECT: Corrosion Problem in the M348A2l1 Semitrailer, Van, Electronic

TO: Director
Coating & Chemical Laboratory
ATTN: AMXCC
Aberdeen Proving Ground, Md. 21005

1. Pursuant to numerous verbal and telephone discussions on subject problem, we wish to reaffirm our request for your concurrent technical assistance in this area. We concur with your proposal to subject the suspected materials from Spencer Stafford, Inc., to exposure to a confined atmosphere under cyclic temperature and humidity variations. Probably one or a combination of these materials is causing the accelerated corrosion of the cadmium plated parts in these vans.

2. Please keep us up to date on the progress of this work so that we can combine your findings with our test data for the requested weekly reports to the Missile Command.

FOR THE COMMANDER:

s/ Joice O. Cox, Jr.
JOICE O. COX, JR.
Major, Armor
Chief, Materials Laboratory

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4 DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final

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13 ABSTRACT

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Cadmium corrosion Alkyd resin enamels Electronic vans Epoxy Vinyl Nitrocellulose - alkyd Nitrocellulose - acrylic						

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